

What is claimed is:

1. An apparatus for supporting a manufacturing tool relative to a workpiece, the apparatus comprising:

a track assembly adapted to be attached to the workpiece;

5 a carriage moveably coupled to the track assembly and moveable relative to the workpiece along a translation axis, the carriage including a tool support adapted to receive and support a manufacturing tool; and

10 an opposing-force support assembly operatively coupled to the carriage and adapted to be secured to the workpiece to at least partially counterbalance a manufacturing force exerted on the workpiece by the manufacturing tool.

2. The apparatus of Claim 1, wherein the opposing-force support assembly includes a clamp-up pin adapted to engage a hole in the workpiece, and a clamp-up actuator operatively coupled to the clamp-up pin and adapted to actuate the clamp-up pin into secure engagement 15 with the workpiece.

3. The apparatus of Claim 1, wherein the opposing-force support assembly includes a vacuum cup assembly adapted to secure to a surface of the workpiece.

20 4. The apparatus of Claim 1, wherein the opposing-force support assembly includes a threaded pin adapted to threadedly engage a threaded hole in the workpiece.

5. The apparatus of Claim 1, wherein the opposing-force support assembly includes:

a first member moveably coupled to the carriage and moveable along a first axis;

25 a first actuator coupled to the first member and to the carriage and adapted to move the first member along the first axis;

a second member moveably coupled to the first member and moveable along a second axis orthogonally oriented with respect to the first axis;

30 a second actuator coupled to the second member and to the first member and adapted to move the second member along the second axis; and

a securing device coupled to the second member and adapted to be secured to the workpiece.



25315

PATENT TRADEMARK OFFICE



6. The apparatus of Claim 5, wherein the securing device is coupled to the second member by a third actuator, the third actuator being adapted to move the securing device along a third axis orthogonally oriented to the first and second axes.

5 7. The apparatus of Claim 6, wherein the second axis is approximately parallel with the translation axis of the carriage, and wherein the first axis is adapted to be approximately parallel with a longitudinal axis of the manufacturing tool.

10 8. The apparatus of Claim 7, wherein the first member is moveably coupled to a pair of elongated members on the carriage, the elongated members being adapted to be approximately parallel with a longitudinal axis of the manufacturing tool.

15 9. The apparatus of Claim 7, wherein the second member is moveably coupled to a pair of elongated members on the first member, the elongated members being adapted to be approximately parallel with the translation axis of the carriage.

10. The apparatus of Claim 1, wherein the track assembly includes at least one rail, and wherein the carriage is rollably coupled to the rail.

20 11. The apparatus of Claim 1, wherein the carriage includes an x-axis portion moveably coupled to the track assembly, and a y-axis portion moveably coupled to the x-axis portion and moveable with respect to the x-axis portion along a y-axis oriented transversely to the translation axis.

25 12. The apparatus of Claim 1, wherein the carriage includes a drive assembly having a drive motor operatively engaging the track assembly and adapted to drive the carriage along the track assembly.

13. An assembly for performing a manufacturing operation on a workpiece, the assembly comprising:

30 a track assembly adapted to be attached to the workpiece;
a carriage moveably coupled to the track assembly and moveable relative to the workpiece along a translation axis, the carriage including a tool support adapted to receive and support a manufacturing tool;



25315

PATENT TRADEMARK OFFICE

BING-I-1003AP

- 14 -

BLACK LOWE & GRAHAM PLLC



816 Second Avenue
Seattle, Washington 98104
206.381.3300 • F: 206.381.3301

a manufacturing tool coupled to the tool support and adapted to be engageable with the workpiece to perform the manufacturing operation on the workpiece; and

an opposing-force support assembly operatively coupled to the carriage and adapted to be secured to the workpiece to at least partially counterbalance a manufacturing force exerted on the workpiece by the manufacturing tool.

14. The assembly of Claim 13, wherein the opposing-force support assembly includes a clamp-up pin adapted to engage a hole in the workpiece, and a clamp-up actuator operatively coupled to the clamp-up pin and adapted to actuate the clamp-up pin into secure engagement with the workpiece.

15. The assembly of Claim 13, wherein the opposing-force support assembly includes a vacuum cup assembly adapted to secure to a surface of the workpiece.

16. The assembly of Claim 13, wherein the opposing-force support assembly includes a threaded pin adapted to threadedly engage a threaded hole in the workpiece.

17. The assembly of Claim 13, wherein the opposing-force support assembly includes:
a first member moveably coupled to the carriage and moveable along a first axis;
a first actuator coupled to the first member and to the carriage and adapted to move the first member along the first axis;

a second member moveably coupled to the first member and moveable along a second axis orthogonally oriented with respect to the first axis;

a second actuator coupled to the second member and to the first member and adapted to move the second member along the second axis; and

a securing device coupled to the second member and adapted to be secured to the workpiece.

18. The assembly of Claim 17, wherein the securing device is coupled to the second member by a third actuator, the third actuator being adapted to move the securing device along a third axis orthogonally oriented to the first and second axes.

19. The assembly of Claim 18, wherein the second axis is approximately parallel with the translation axis of the carriage, and wherein the first axis is adapted to be approximately parallel with a longitudinal axis of the manufacturing tool.



25315

PATENT TRADEMARK OFFICE

20. The assembly of Claim 19, wherein the first member is moveably coupled to a pair of elongated members on the carriage, the elongated members being adapted to be approximately parallel with a longitudinal axis of the manufacturing tool.

5

21. The assembly of Claim 19, wherein the second member is moveably coupled to a pair of elongated members on the first member, the elongated members being adapted to be approximately parallel with the translation axis of the carriage.

10 22. The assembly of Claim 13, wherein the track assembly includes at least one rail, and wherein the carriage is rollably coupled to the rail.

15 24. The assembly of Claim 13, wherein the carriage includes an x-axis portion moveably coupled to the track assembly, and a y-axis portion moveably coupled to the x-axis portion and moveable with respect to the x-axis portion along a y-axis oriented transversely to the translation axis.

20 25. The assembly of Claim 13, wherein the carriage includes a drive assembly having a drive motor operatively engaging the track assembly and adapted to drive the carriage along the track assembly.

26. The assembly of Claim 13, wherein the manufacturing tool includes a drill and the manufacturing operation includes a drilling operation.

25 27. A method of performing a manufacturing operation on a workpiece, the method comprising:

30 moveably supporting a manufacturing assembly proximate a surface of the workpiece, the manufacturing assembly including a manufacturing tool and an opposing-force support assembly, the manufacturing assembly being moveable along a translation direction that is at least partially along a direction perpendicular to a local normal to a surface of the workpiece;

applying a manufacturing force against the workpiece using the manufacturing tool, the manufacturing force being at least partially along the local normal; and

simultaneously with applying the manufacturing force against the workpiece, applying an opposing force against the workpiece using the opposing-force support



25315

PATENT TRADEMARK OFFICE

- 16 -

BING-1-1003AP

BLACK LOWE & GRAHAM PLLC

816 Second Avenue
Seattle, Washington 98104
206.381.3300 • F: 206.381.3301

assembly, the opposing force being in a direction substantially parallel with and opposite to the manufacturing force.

28. The method of Claim 27, wherein moveably supporting a manufacturing assembly proximate a surface of the workpiece includes slideably supporting the manufacturing assembly on a rail positioned proximate the surface of the workpiece.

29. The method of Claim 27, wherein applying an opposing force against the workpiece includes inserting a clamp-up pin into a hole in the workpiece and actuating a clamp-up actuator operatively coupled to the clamp-up pin.

30. The method of Claim 27, wherein applying an opposing force against the workpiece includes applying a vacuum pressure to a surface of the workpiece.

31. The method of Claim 27, wherein applying an opposing force against the workpiece includes inserting a threaded member into a threaded hole in the workpiece and actuating an actuator operatively coupled to the threaded member.

32. The method of Claim 27, wherein applying an opposing force against the workpiece includes applying an opposing force that at least approximately counterbalances the manufacturing force.

33. The method of Claim 27, further comprising moving the manufacturing tool along the translation direction simultaneously with applying the opposing force against the workpiece using the opposing-force support assembly.

34. The method of Claim 27, further comprising performing the manufacturing operation on the workpiece using the manufacturing tool.

35. The method of Claim 34, wherein the manufacturing tool includes a drill and the manufacturing operation includes a drilling operation.



25315

PATENT TRADEMARK OFFICE

BING-1-1003AP

- 17 -

BLACK LOWE & GRAHAM PLLC

816 Second Avenue
Seattle, Washington 98104
206.381.3300 • F: 206.381.3301